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(54) **Portable type radio equipment**

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Description

[0001] The present invention relates to a radio equipment of portable type, particularly to a radio equipment of portable type made in one unit with an antenna and capable of reducing the influence of the things around the antenna upon the characteristics of the antenna.

[0002] Recently, a radio equipment or terminal of portable type has become thinner and more compact. A radio equipment of portable type should be at present very easy to carry with. Therefore, thin and compactness of the equipment is very important features.

[0003] On the other hand, there is a problem that a human body affects an antenna mounted on radio equipment. A human body absorbs and scatters a radio wave of the frequency used in the radio equipment of portable type. Further, a human body fluctuates the antenna impedance used nearby. Generally, in respect of a high frequency band, a human body acts as dielectric media with a permittivity of 50 or higher. Consequently, a human body deteriorates the radiation characteristics of an antenna.

[0004] In addition, as the radio equipment of portable type becomes thin and compact, an antenna is positioned closer to the ear of the equipment user. This closer distance to the ear makes deterioration of the antenna characteristics more serious.

[0005] The inventors of the present invention measured the influence of a human body on the deterioration of the antenna characteristics, and obtained the results as shown in FIG. 1. The experiment used a radio equipment of portable type of 2 GHz and measured the influence of a human body on the antenna. FIG. 1 shows the deterioration of the antenna gain caused by the impedance fluctuation while the radio equipment is being operated, taking the equipment thickness as a parameter. As seen from FIG. 1, when the equipment thickness becomes thinner than 20 mm, the possibility of contacting the ear to the antenna increases, and when the antenna comes in contact with the ear, the antenna gain is largely deteriorated.

[0006] As mentioned above, the cause of this deterioration is the fluctuation in the antenna impedance due to the influence of a human body. A human body has a very high dielectric constant. Thus, when the antenna is approached to a human body, the electrical length of the antenna is regarded as to be equivalently long. In this case, the antenna resonance frequency deviates from a desired value, and the antenna impedance changes accordingly.

[0007] Therefore, even if the antenna impedance is adjusted to the optimum level in the radio equipment of portable type itself, the antenna impedance will shift from the optimum value when it is brought close to a human body.

[0008] Further, when the antenna impedance is deteriorated, the transmission power of the radio equipment of portable type may be lowered. This problem will be

explained hereinafter.

[0009] To radiate a radio wave from an antenna, the antenna must be powered first of all. The optimum condition to power the antenna is that the impedance of a feed line is the same value as the impedance of that antenna.

[0010] When the antenna impedance changes from the optimum value, the power supplied through the feed line is reflected by the input end of the antenna and returned to a transmitting amplifier. Therefore, the power outputted from the amplifier to the antenna is reduced.

[0011] Moreover the reflected power deteriorates the amplifier performance, such as gain and operation efficiency, and causes deterioration of the transmission performance of the radio equipment itself.

[0012] As a means of solving this problem, a method of examining the reflection coefficient between the amplifier and antenna has been proposed. This proposal includes the power amplifier disclosed by Jpn. Pat. Appln. KOKAI Publication No. 10-341117. This conventional power amplifier detects the current consumption in the power amplifier and the power reflected by an antenna, and supplies these detected signals to the control circuit. This control circuit sends a control signal to a variable phase snifter based on the both detected signals, and corrects phase shifts occurred between the power amplifier and antenna.

[0013] Since this prior art power amplifier corrects only phase shifts, the evaluation quantity changing range is narrow and the phase shifts can be corrected by measuring the evaluation quantities. However, if a shift has two vectors, that is, the phase and amplitude directions of a reflection coefficient, as in the antenna of a cellular phone, the correction becomes difficult by only the above two evaluation quantities. Moreover, the antenna impedance must be checked even while communication is not made. Otherwise, communication has to be started in bad conditions, causing a communication failure. In the radio equipment of portable type, it is resulted from the high probability of changing the surrounding conditions upon start of communication. For example, when a call comes in standby mode, a mobile terminal is taken out from a pocket, held by hand, set to conversation mode, and attached to a head. The conditions around the antenna are changed three times in a very short time.

[0014] The above-mentioned conventional method can check the impedance only while communication is being made in some types of the system. In the CDMA system, for example, only an incoming call can be accepted in standby mode, and the above-mentioned operation is impossible. Sending a radio wave unnecessarily except when making communication causes troubles in other systems, and is controlled by the Radio Law.

[0015] EP 1 093 272 describes a transmitter and receiver designed to compensate for load fluctuations which induce mismatching of impedance between an antenna and a transmission signal path.

[0016] US 5 564 086 describes a method and appara-

tus for enhancing characteristics of a linear transmitter which operates under varying antenna loads without having to use an isolator.

[0017] EP 0 404 150 describes a circuit arrangement which compensates for mistuning of the antenna resonant circuit.

[0018] EP 0 459 440 describes a transmitter apparatus which has a variable impedance circuit to allow the impedance to be changed in response to the battery voltage.

[0019] US 4 965 607 describes an antenna coupler with an adjustable impedance for use in high frequency swept antenna systems.

[0020] As explained above, there is a problem in the conventional radio equipment of portable type. Antenna characteristics are deteriorated by bad matching between a transmitter and an antenna, caused by the surrounding conditions, particularly coming close to a human body.

[0021] An object of the present invention is to provide a radio equipment of portable type capable of making good communication, which has a circuit configuration matched with an antenna without an influence of an ambience around the antenna.

[0022] According to an aspect of the invention, there is provided a radio communication equipment as recited in Claim 1.

[0023] According to a still further aspect of the invention, there is provided a method as recited in Claim 10.

[0024] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a graph showing the relation between the thickness of a mobile phone and the mismatching loss of an antenna;

FIG. 2 is a block diagram showing schematically a circuit configuration of a radio equipment of portable type according to one embodiment of the present invention;

FIG. 3 is a flow chart showing the operations of the radio equipment of portable type shown in FIG. 1;

FIG. 4 is another flow chart showing the operations of the radio equipment of portable type shown in FIG. 1;

FIG. 5 is a block diagram showing schematically a circuit configuration of a radio equipment of portable type according to another embodiment of the present invention;

FIG. 6 is a block diagram showing the exemplary structure of the receiving circuit shown in FIG. 5;

FIG. 7 is a flow chart showing the operations of the radio equipment of portable type shown in FIGS. 5 and 6;

FIG. 8 is block diagram showing schematically a circuit configuration of a radio equipment of portable type which does not include both the first and second transmitting circuits of the claimed invention, by way

of example;

FIG. 9 is a block diagram showing schematically a circuit configuration of a radio equipment of portable type according to a further embodiment of the present invention; and

FIG. 10 is a block diagram showing schematically the circuit of a radio equipment of portable type according to a yet further embodiment of the present invention.

[0025] There will be described embodiments of the present invention with reference to the accompanying drawings. FIG. 2 is a block diagram showing a radio equipment of portable type according to one embodiment of the present invention.

[0026] As shown in FIG. 2, an antenna 101 is connected to a matching circuit 102 having the function of matching the impedance of an antenna. The matching circuit 102 is connected to a changeover switch 103. One end of the changeover switch 103 is connected to a reflection phase detector 104 for detecting the phase of the reflection signal reflected by the antenna, and the other end is connected to a transmitter-receiver 105 for generating a transmitting signal.

[0027] The transmitter-receiver 105 is connected to a power supply 107 through an ammeter 106 for detecting the current value of the supply power. A control-circuit 108 is connected to the reflection phase detector 104 and ammeter 106, receiving a phase signal and a current signal detected by the detector 104 and ammeter 106. The control circuit 108 sends a control signal to the matching circuit 102 and changeover switch 103, controlling these circuits.

[0028] Here, the matching circuit 102, comprising an inductance and a variable capacitance element, can change the impedance value of the antenna 101 when the variable capacitance element is varied by the control signal from the control circuit 108.

[0029] The reflection phase detector 104, containing a transmitting circuit (not shown), measures what extent the antenna 101 changes the phase of the signal transmitted from the inside transmitting circuit (not shown), by receiving the signal reflected by the antenna. As already described, the reflection signal from the terminal of the antenna 101 is changed by the circumstances around the antenna 101. This change in the reflection signal is as already explained with the prior art is generated based on the antenna impedance change, and can be considered equivalent to the impedance change. Therefore, if the correlation between the reflection phase S_p and the state of the antenna 101 is previously examined, it is possible to know the state of the antenna by the value of the reflection phase S_p from the antenna 101. It is also possible to determine the method of adjusting the matching circuit 102 by the measured reflection phase S_p , in order to return the reflection phase S_p to a reference level. Namely, by detecting the reflection signal from the antenna 101, the impedance of the antenna 101 can be

estimated. If the value of the variable capacitance element of the matching circuit 102 is changed based on the impedance of the antenna 101, the transmission power can be held optimum.

[0030] The power supply circuit 107 powers the transmitter-receiver 105. The supplied power is modulated based on the digital data signal, e.g., audio and video signals, sent from a data signal generator (not shown), and it is converted also to a transmission frequency, thereby a transmitting signal is generated and transmitted from the antenna 101. The antenna 101 transmits a transmitting signal into the air, but a part of the signal returns to the transmitter-receiver 105 as a reflected wave. The reflection quantity of this reflected signal changes depending on the impedance value of the antenna 101.

[0031] The impedance of the antenna 101 is changed by the circumstances surrounding the antenna, and the returned reflection signal is also changed. This reflection signal changes the gain and efficiency of the transmitting amplifier in the transmitter-receiver 105. Therefore, the fluctuation in this reflection signal causes a fluctuation in the current consumption of the transmitter-receiver 105. An ammeter 106 measures the fluctuation in the current consumption, and a current level SI is sent to the control circuit 108. The value of this current level SI is closely related to the situation in which the antenna is placed. Therefore, the current level SI can be used as an evaluation function for adjustment of the matching circuit.

[0032] The signal received by the antenna 101 is supplied to the transmitter-receiver 105 through the matching circuit 102 and changeover switch 103. Processing of the received signal is equivalent to ordinary processing of a mobile terminal or at a base station, and detailed explanation will be omitted.

[0033] There will now be described the operations of the control circuit 108 with reference to the flow chart of FIG. 3.

[0034] First, receiving the control signal from the control circuit 108, the movable contact of the switch 103 is connected to a first fixed contact Sa, setting a phase detection mode to detect the phase of the reflection signal (step S1). Next, the transmitting circuit (not shown) of the phase detector 104 sends a phase detection signal to the control circuit 108, detecting the phase Sp of the reflection signal from the antenna 101 (step S2).

[0035] Next, the movable contact of the switch 103 is connected to a second fixed contact Sb, setting a current detection mode for detecting a transmission current (step S3). Therefore, the transmission power is supplied to the transmitter-receiver 105, the transmitting signal is supplied from the transmitter-receiver 105 to the antenna 101, and the ammeter 106 detects the current level SI of the power supplied to the transmitter-receiver 105 (step S4). The phase Sp and the current level SI of this reflection signal are given to the control circuit 108, where Sp and SI are compared to the reference values Sp0 and SI0 (step S5). The reference values Sp0 and SI0 are pre-

viously measured under the condition where the antenna 101 is not being close to the surrounding things, and the measurement value is stored in the storage circuit. When the phase Sp and current level SI are deviated from the previously determined reference values Sp0 and SI0, respectively, the matching circuit 102 is adjusted. (Step S6) After this adjustment, the phase Sp and current value SI of the reflection signal will be measured in the same way, and the evaluation of these two values will be repeated.

10 The adjustment and measurement will be repeated until the values of Sp and SI reach the reference values Sp0 and SI0, respectively. When the values of Sp and SI reach the reference values Sp0 and SI0, respectively, communication will be started in transmitting/receiving mode by utilizing the transmitter-receiver 105 (step S7).

[0036] Since communication is started after the antenna impedance is set to the optimum level, as described above, the influence of the circumstances upon the mobile terminal operation is eliminated and communication can be started in an optimum state.

[0037] Next, another control method in the circuit shown of FIG. 2 will be explained with reference to the flow chart shown in FIG. 4. First, the movable contact of the switch 103 is connected to a fixed contact Sa by the control signal from the control circuit 108, and phase detection mode is set to detect the phase of the reflection signal (step S11). Next, a transmitting signal is transmitted from the transmitting circuit (not shown) in the phase detector 104. the reflection signal from the antenna 101 is detected, and the phase Sp of the reflection signal is detected (step S12).

[0038] Next, a method of adjusting the matching circuit 102 is determined based on the value of the detected phase Sp (step S13). In step 13, when comparing the current level Sp to the reference value Spa, the method of adjusting the capacitance element of the matching circuit depending on the phase shift value Sp, that is, whether to increase or decrease the capacitance is determined. When the phase Sp of the reflection signal is largely shifted depending upon the design of the amplifier which comprises the transmitter-receiver, the value of the capacitance element of the matching circuit is increased or decreased to approximate the value Sp to the reference value. Whether to increase or decrease the capacitance, is determined.

[0039] After the adjustment method is determined, the movable contact of the switch 103 is connected to a second fixed contact Sb, and phase detection mode is set to detect the phase of the reflection signal (step S14). Next, the current level SI is detected by the ammeter 106 (step S13). The current level SI is compared to the reference value SI0 (step S16). This reference value SI0 is, as explained above, is previously measured under the condition where the antenna 101 is not close to the surrounding things, and the measurement value is stored.

[0040] When the current level SI is shifted from the reference value SI0, the matching circuit 102 is adjusted (step S17). Measurement of the current value SI and

evaluation will be repeated until the current level SI reaches the reference value SI0. When the current level SI reaches the reference value, communication will be started in transmitting/receiving mode by utilizing the transmitter-receiver 105 (step S18).

[0041] Therefore, in such control, only the current value SI is used as an evaluation function for adjusting the matching circuit 102. Accordingly, the time required by the adjustment can be reduced. As explained hereinbefore, the above-mentioned embodiment improves the communication performance of a mobile terminal when an antenna comes close to the surrounding things including a human body. FIG. 5 shows the configuration of the phase detector 104 of a radio equipment of portable type shown in FIG. 2. The blocks except the phase detector 104 are the same as those in FIG. 2, and the explanation thereof will be omitted.

[0042] As shown in FIG. 5, the phase detector 104 is provided with a transmitting circuit 104-1 which transmits a signal for measuring the phase of the reflection signal, and a receiving circuit 104-2 which receives the reflection signal as a reflected wave reflected by the antenna 101. The transmitting circuit 104-1 and the receiving circuit 104-2 are connected to a circulator 104-3. The circulator 104-3 is connected to a switch 103 through a delay line 104-4.

[0043] The transmitting circuit 104-1 and the receiving circuit 104-2 include a phase modulator/demodulator. The circulator 104-3 sends the transmitting signal Si from the transmitting circuit 104-1 to the receiving circuit 104-2, sends the transmitting signal generated from the transmitting circuit 104-1 to the antenna 101 through the delay line 104; and supplies the reflection signal reflected by the antenna 101 to the receiving circuit 104-2 through the delay line 104-4. Namely, the circulator 104-3 selectively supplies the receiving circuit 104-2 with the transmitting signal from the transmitting circuit 104-1 and the reflection signal from the antenna 101. Further, the delay line 104-4 uses an element such as an acoustic surface-wave filter 10 to give a relatively long delay to the transmitting signal going to the antenna 101 and the reflection signal coming from the antenna.

[0044] The receiving circuit 104-2 has the structure as shown in FIG. 6. The receiving circuit 104-2 includes a demodulator 104-2A which detects the transmitting signal or the reflection signal from the circulator 104-3, and demodulates them. The phase of the transmitting signal or the reflection signal demodulated by this demodulator 104-2A is stored as phase data in the storage circuit 104-2B. The stored phase data of the demodulated transmitting signal and reflection signal is sent to the comparator 104-2C, where the phase-difference between the two signals is detected. The detected phase-difference signal is supplied to the control circuit 108.

[0045] Description will now be given on the operations of the receiving circuit 104 and the control circuit 108 which have the phase detection function shown in FIG. 5 and FIG. 6, with reference with the flow chart of FIG.

7. In a first step, the phase is detected in free space of the antenna 101 in order to determine a reference value of the phase. The following operations are executed under the condition where no things come close to the antenna.

[0046] First, the movable contact of the switch 103 is connected to the fixed contact Sa by the control signal from the control circuit 108, and phase detection mode is set to detect the phase of the reflection signal (step S21). Next, a transmitting signal is transmitted from the transmitting circuit 104-1. At this time, the signal is non-modulated, and the pulse width is fixed to be 1/2 or lower than the delay time of the delay line 104-4.

[0047] The circulator 104-3 is previously adjusted, so that a part of the transmitted signal, that is, the transmitting signal S1 is sent directly to the receiving circuit 104-2 and the remainder, that is, the transmitting signal S2 is sent to the delay line 104-4. The receiving circuit 104-2 detects and demodulates the transmitting signal S1, and collects the phase data P1 of that signal, and starts measuring the time passing after the start of receiving the transmitting signal S1 (step S23).

[0048] The transmitting signal S2 sent to the delay line 104-4 is transmitted to the antenna 101 through the delay line 104-4, the switch 103 and the matching circuit 102. The transmitting signal is reflected by the antenna 101 according to the impedance difference between the antenna 101 and the matching circuit 102. This reflected signal S2 is returned to the circulator 104-3 through the matching circuit 102, the switch 103 and the delay line 104-4. The reflected signal is applied to the receiving circuit 104-2 by the circulator 104-3. The receiving circuit 104-2 detects and demodulates the reflected signal S2, thereby obtaining the phase data P2 of the reflected signal S2 (step S24).

[0049] To confirm the reflected signal S2, the time measured after reception of the transmitting signal S1 is used. Namely, the back-and-forth delay time given by the delay line 104-4 is previously measured. The input signal to be received after that delay time is judged to be the reflection signal S2 reflected by the antenna. As the signal S2 is delayed by the delay line 104-4, interference will not occur between the transmitting signal S1 and the reflection signal S2.

[0050] The comparator 104-2C compares the phase data P1 of the transmitting signal S1 with the phase data P2 of the reflection signal S2, and sends the phase-difference data P to the control circuit 108. The control circuit 108 stores in the memory this phase-difference data P indicating the state of the antenna in free space as a reference (step S25).

[0051] As described above, the reference is determined.

[0052] Next, a measurement sequence will be described in an actual condition or environment. A method of measuring a phase in the actual condition is the same as the method of measuring the reference. Thus, procedures in the actual phase measuring method are the

same as that of the steps S21 to S25. Thus, description of the procedures will be omitted.

[0053] In the actual phase measuring method, after the step S26, the control circuit 108 compares the measured phase with the reference value.

[0054] Next, the method of adjusting the matching circuit 102 is determined based on the phase S_p of the detected reflection signal (step S27). As already explained, this method determines a method of adjusting the capacitance element in the matching circuit according to the phase of the reflection signal when comparing the current value with the reference value, namely, whether to increase or decrease the capacitance. When the phase shift of the reflection signal is largely depending upon the design of the amplifier which comprises the transmitter-receiver, the value of the capacitance element of the matching circuit is increased or decreased to approximate the current value to the reference value. Whether to increase or decrease the capacitance is determined.

[0055] After the adjustment method is determined, the movable contact of the switch 103 is connected to the fixed contact S_b , and current detection mode is set to detect the transmission current (step S28). Next, the current level S_I is detected by the ammeter 106 (step S29). The current level S_I is compared to the reference value S_{IO} (step S30). This reference value S_{IO} is, as explained above, is previously measured 25 under the conditions where the antenna 101 is not close to the surrounding things, and the measurement value is stored.

[0056] When the current level S_I is shifted from the reference value S_{IO} , the matching circuit 102 is adjusted (step S31). Measurement of the current value S_I and evaluation will be repeated until the current level S_I reaches the reference value S_{IO} . When the current level S_I reaches the reference value S_{IO} , communication will be started in transmitting/receiving mode by utilizing the transmitter-receiver 105 (step S32).

[0057] As explained above, the communication performance of a mobile terminal when a human body or other surrounding things come close to the antenna, can be improved.

[0058] The frequencies used by the phase detector 108 and transmitter-receiver 105 need not to be strictly coincident. The effect of the present invention can be obtained with the similar frequencies.

[0059] The reflection phase detector 108 preferably uses a frequency of IMS band (2.4 GHz). With this frequency, a signal to leak from the antenna 101 will not affect other mobile terminals.

[0060] FIG. 9 shows the circuit of a radio equipment of portable type according to a further embodiment of the present invention. In this circuit, a common unit 110 is used for the switch 103 in the radio equipment of portable type shown in FIG. 2. The common unit 110 is composed of a filter, for example. By making the frequency F_1 of the transmitting signal SF_1 generated by the phase detector 104 different from the frequency of the transmitting

signal SF_2 generated by the transmitter-receiver 105, the common unit 110 is given the same function as the switch 103. In other words, since the reflection wave generated by the phase detector 104 and reflected by the antenna has the frequency of SF_1 , it is prevented from being supplied to the phase detector 104 through the common unit 110. Since the reflection wave generated by the transmitter-receiver 105 and reflected by the antenna has the frequency of SF_2 , it is prevented from being supplied to the phase detector 104 through the common unit 110. If a radio equipment of portable type in which ISM band (2.4 GHz) is generated by the phase detector 104 is used, it is possible to check the antenna state of the portable radio equipment and to adjust the matching circuit 102 without affecting other radio equipments.

[0061] Furthermore, FIG. 10 shows a circuit configuration of a radio equipment of portable type according to yet another embodiment of the invention. In FIG. 10, a second antenna 101-2 is provided in addition to the first antenna 101 and a matching circuit 102 is connected between the second antenna 101-2 and the ground, instead of the matching circuit 102 connected between the first antenna 101 and the switch 103. The second antenna 101-2 is so called a parasitic element, which can electro-magnetically coupled to the first antenna 101 under the control of an impedance of the matching circuit 102. If the first and second antennas 101, 101-2 are coupled each other, the antenna characteristics of the first antennas 101-2 are changed. Accordingly, a good radio communication can be achieved with a suitable antenna characteristics by matching an impedance of the matching circuit 102 under the control of the control section 108, as described in the same manner in the aforementioned embodiments, even if the antenna characteristic of the first antenna 101 shown in FIG. 10 is varied when the first antenna 101 is approached to the human body. The matching circuit 102 may be located between a base or a tip portion of the second antenna 101-2 and the ground. In this configuration, there is an advantage that the gain is not prevented from being decreased due to the electrical power loss in the matching circuit 102, because the matching circuit 102 is not arranged between the first antenna 101 and the transmitter and receiver 105.

[0062] It is apparent that although the above-mentioned embodiment uses a mobile terminal, the present invention is not limited to a mobile terminal and can be applicable to a variety of radio equipments having an antenna, including a radio base station, for example.

[0063] Although, the above embodiments employ a single matching circuit, which is a combination of the inductor and the variable capacitor such as a varactor diode whose capacitance is changed in accordance with an applied bias voltage. However, the circuit of the radio equipment may be provided with a plurality of matching circuits each having a fixed capacitor and inductor, and a high frequency switching circuit for switching one of the matching circuits under the control of the control circuit 108. According to this circuit, it is possible to obtain the

same advantage as that of the embodiments in which the matching circuit is controlled.

[0064] In the embodiments described above, the ammeter 106 is utilized for estimating the electric power supplied to the transmitter-receiver 105, which is drive by a relatively low and substantially constant voltage. If a variable voltage drives the transmitter-receiver 105, instead of the relatively low and substantially constant voltage, it is required to use a power meter for measuring the power supplied to the transmitter-receiver 105, or use not only the ammeter for measuring a current supplied to the transmitter-receiver 105 but also a voltage meter for measuring the voltage applied to the transmitter-receiver 105 and calculate the power from the measured current and voltage.

Claims

1. A radio communication equipment comprising:

a power supply (107) configured to supply an electric power;
 a first transmitting circuit (105) configured to generate a first transmitting signal for communicating with the other communication equipment, which is energized by the power supply (107);
 a power detection circuit (106) configured to detect the electric power supplied to the first transmitting circuit (105) and generate a power detection signal;
 an antenna (101), having an antenna impedance, to which the first transmitting signal is supplied, and which generates an antenna reflection signal having a certain phase depending on the first transmitting signal;
 an impedance matching circuit (102), having a variable impedance, configured to adjust the variable impedance to match the antenna (101) with the first transmitting circuit (105); and
 a control circuit (108) configured to control the impedance matching circuit (102) to set the variable impedance depending on the power detection signal;

characterized in that the radio communication equipment further comprises:

a phase detection circuit (104) configured to generate a phase detection signal, the phase detection circuit (104) including
 a second transmitting circuit (104-1) configured to generate a second transmitting signal having a first phase, and supply the second transmitting signal to the antenna (101), the antenna (101) generating an antenna (101) reflection signal having a second phase depending on the sec-

ond transmitting signal, and

a receiving circuit (104-2) configured to receive the second transmitting signal from the second transmitting circuit (104-1) and the antenna reflection signal from the antenna (101), and detect a phase-difference between the first and second phases to generate the phase detection signal; and

the control circuit (108) is configured to control the impedance matching circuit (102) to set the variable impedance depending on the phase detection signal in addition to the power detection signal.

2. The radio communication equipment according to claim 1, **characterized in that** the radio communication equipment further comprises a selecting circuit (103) configured to select one of the phase detection circuit (104) and the first transmitting circuit (105) and connect the selected one of the phase detection circuit (104) and the first transmitting circuit (105) to the antenna (101), and the control circuit (108) is configured to control the selecting circuit (103) to receive the phase detection signal and the power detection signal.

3. The radio communication equipment according to claim 2, **characterized in that** the control circuit (108) is configured to generate first and second selection signals and to supply the first and second selection signals to the selecting circuit (103), the selecting circuit (103) being configured to connect the antenna (101) to the phase detection circuit (104) in response to the first selecting signal, and to connect the antenna (101) to the transmitting circuit (105, 104-1) in response to the second signal.

4. The radio communication equipment according to claim 1, **characterized in that** the control circuit (108) is configured to store a reference phase signal and a reference power signal, and to adjust the impedance of the impedance matching circuit (102) in accordance with the comparison between the phase detection signal and the reference phase signal, and between the power detection signal and the reference power signal.

5. The radio communication equipment according to claim 3, **characterized in that** the control circuit (108) is configured to determine a method of adjusting the impedance matching circuit (102) depending on the comparison between the phase detection signal and the reference phase signal, and to compare the power detection signal with the reference power signal to set the variable impedance in the impedance matching circuit (102).

6. The radio communication equipment according to

claim 5, **characterized in that** the adjustment method corresponds to one of increasing and decreasing the variable impedance.

7. The radio communication equipment according to claim 1, **characterized by** further comprising a second antenna (101-2) connected to the antenna (101), the first and second antennas (101, 101-2) being electro-magnetically coupled to each other. 5
8. The radio communication equipment according to claim 1, **characterized in that** the phase detection circuit (104) further includes a delay line (104-4) configured to delay the second transmitting signal from the second transmitting circuit (104-1) to the antenna (101), and delay the antenna (101) reflection signal from the antenna (101) to the receiving circuit (104-2); and 10
a circulator (104-3) configured to circulate the delayed antenna (101) reflection signal to the receiving circuit (104-2), and circulate the second transmitting signal from the second transmitting circuit (104-1) to the delay line (104-4) and the receiving circuit (104-2). 15
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9. The radio communication equipment according to claim 1, **characterized in that** the first transmitting signal has a first frequency, the second transmitting signal has a first phase and a second frequency, and the radio communication equipment further comprises a filter circuit configured to pass the first and second transmitting signal to the antenna (101) and the antenna (101) reflection signal to the phase detection circuit (104), respectively, and prevent the antenna (101) reflection signal from being transferred to the first transmitting circuit (105). 25
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10. A method of adjusting a variable impedance in an impedance matching circuit (102) connected to an antenna (101), 40
characterized by comprising:
supplying an electric power to a first transmitting circuit (105) to generate a first transmitting signal and supplying the first transmitting signal to the antenna (101) through the impedance matching circuit (102) and communicating with the another communication equipment; 45
detecting the electric power supplied to the first transmitting circuit (105) and generate a power detection signal; 50
detecting an antenna reflection signal having a phase, which is returned from the antenna (101); and
setting the variable impedance of an impedance matching circuit (102) depending on the power detection signal, in order to match the antenna (101) with the first transmitting circuit (105): 55

characterized in that

the setting the variable impedance includes generating a second transmitting signal having a first phase by means of a second transmitting circuit (104-1), and supply the second transmitting signal to the antenna (101) which generates an antenna (101) reflection signal having a second phase depending on the second transmitting signal;
receiving the second transmitting signal and the antenna reflection signal;
detecting a phase-difference between the first and second phases to generate a phase detection signal, and
controlling the variable impedance depending on the phase detection signal in addition to the power detection signal.

Patentansprüche

1. Ein Gerät zur Funkkommunikation, umfassend:

ein Netzteil (107), dazu ausgebildet, eine elektrische Leistung zuzuführen;
ein erster Übertragungsschaltkreis (105), dazu ausgebildet, ein erstes Übertragungssignal zum Kommunizieren mit den anderen Kommunikationsgeräten zu erzeugen, welcher Schaltkreis von dem Netzteil (107) versorgt bzw. energetisiert wird;
einen Leistungsdetektionsschaltkreis (106), dazu ausgebildet, die an den ersten Übertragungsschaltkreis (105) zugeführte elektrische Leistung zu detektieren und ein Leistungsdetektionssignal zu erzeugen;
eine Antenne (101) mit einer Antennenimpedanz, der das erste Übertragungssignal zugeführt wird und die ein Antennenreflexionssignal mit einer bestimmten Phase in Abhängigkeit von dem ersten Übertragungssignal abhängt, erzeugt;
einen Impedanzanpassungsschaltkreis (102) mit einer variablen Impedanz, dazu ausgebildet, die variable Impedanz anzupassen, um die Antenne (101) an den ersten Übertragungsschaltkreis (105) anzupassen; und
ein Steuerungsschaltkreis (108), dazu ausgebildet, den Impedanzanpassungsschaltkreis (102) zu steuern, um die von dem Leistungsdetektionssignal abhängende, variable Impedanz einzustellen;

dadurch gekennzeichnet, dass das Funkkommunikationsgerät ferner umfasst:

einen Phasendetektionsschaltkreis (104), dazu

- ausgebildet, ein Phasendetektionssignal zu erzeugen, wobei der Phasendetektionsschaltkreis (104) einen zweiten Übertragungsschaltkreis (104-1) umfasst, dazu ausgebildet, ein zweites Übertragungssignal mit einer ersten Phase zu erzeugen und das zweite Übertragungssignal der Antenne (101) zuzuführen, wobei die Antenne (101) ein Antennen (101)-Reflexionssignal mit einer von dem zweiten Übertragungssignal abhängenden, zweiten Phase erzeugt, und
- einen Empfangsschaltkreis (104-2), dazu ausgebildet, das zweite Übertragungssignal von dem zweiten Übertragungsschaltkreis (104-1) und das Antennenreflexionssignal von der Antenne (101) zu empfangen und eine Phasendifferenz zwischen der ersten und zweiten Phase zu detektieren, um das Phasendetektionssignal zu erzeugen; und
- wobei der Steuerungsschaltkreis (108) dazu ausgebildet ist, den Impedanzanpassungsschaltkreis (102) zu steuern, um die von dem Phasendetektionssignal abhängende variable Impedanz zusätzlich zu dem Leistungsdetektionssignal einzustellen.
2. Das Funkkommunikationsgerät nach Anspruch 1, **dadurch gekennzeichnet, dass** das Funkkommunikationsgerät ferner umfasst: einen Auswahlsschaltkreis (103), dazu ausgebildet, einen der Phasendetektionsschaltkreise (104) und den ersten Übertragungsschaltkreis (105) auszuwählen und den ausgewählten einen der Phasendetektionsschaltkreise (104) und den ersten Übertragungsschaltkreis (105) mit der Antenne (101) zu verbinden, und wobei der Steuerungsschaltkreis (108) dazu ausgebildet ist, den Auswahlsschaltkreis (103) zu steuern, um das Phasendetektionssignal und das Leistungsdetektionssignal zu empfangen.
 3. Das Funkkommunikationsgerät nach Anspruch 2, **dadurch gekennzeichnet, dass** der Steuerungsschaltkreis (108) dazu ausgebildet ist, ein erstes und zweites Auswahlssignal zu erzeugen und das erste und zweite Auswahlssignal dem Auswahlsschaltkreis (103) zuzuführen, wobei der Auswahlsschaltkreis (103) dazu ausgebildet ist, die Antenne (101) mit dem Phasendetektionsschaltkreis (104) in Antwort auf das erste Auswahlssignal zu verbinden und die Antenne (101) mit dem Übertragungsschaltkreis (105, 104-1) in Antwort auf das zweite Signal zu verbinden.
 4. Das Funkkommunikationsgerät nach Anspruch 1, **dadurch gekennzeichnet, dass** der Steuerungsschaltkreis (108) dazu ausgebildet ist, ein Referenzphasensignal und ein Referenzleistungssignal zu speichern und die Impedanz des Impedanzanpassungsschaltkreises (102) in Übereinstimmung mit dem Vergleich zwischen dem Phasendetektionssignal und dem Referenzphasensignal sowie zwischen dem Leistungsdetektionssignal und dem Referenzleistungssignal einzustellen.
 5. Das Funkkommunikationsgerät nach Anspruch 3, **dadurch gekennzeichnet, dass** der Steuerungsschaltkreis (108) dazu ausgebildet ist, ein Verfahren zum Einstellen des Impedanzanpassungsschaltkreises (102) in Abhängigkeit von dem Vergleich zwischen dem Phasendetektionssignal und dem Referenzphasensignal zu bestimmen, und das Leistungsdetektionssignal mit dem Referenzleistungssignal zu vergleichen, um die variable Impedanz in dem Impedanzanpassungsschaltkreis (102) einzustellen.
 6. Das Funkkommunikationsgerät nach Anspruch 5, **dadurch gekennzeichnet, dass** das Einstellverfahren einem aus dem Vergrößern und Verkleinern der variablen Impedanz entspricht.
 7. Das Funkkommunikationsgerät nach Anspruch 1, **dadurch gekennzeichnet, dass** es ferner eine mit der Antenne (101) verbundene, zweite Antenne (101-2) umfasst, wobei die erste und zweite Antenne (101, 101-2) elektromagnetisch miteinander gekoppelt sind.
 8. Das Funkkommunikationsgerät nach Anspruch 1, **dadurch gekennzeichnet, dass** der Phasendetektionsschaltkreis (104) ferner umfasst: eine Verzögerungsleitung (104-4), dazu ausgebildet, das zweite Übertragungssignal von dem zweiten Übertragungsschaltkreis (104-1) an die Antenne (101) zu verzögern und das Antennen(101)-Reflexionssignal von der Antenne (101) zu dem Empfangsschaltkreis (104-2) zu verzögern; und einen Zirkulator (104-3), dazu ausgebildet, das verzögerte Antennen (101)-Reflexionssignal zu dem Empfangsschaltkreis (104-2) zu zirkulieren und das zweite Übertragungssignal von dem zweiten Übertragungsschaltkreis (104-1) zu der Verzögerungsleitung (104-4) und dem Empfangsschaltkreis (104-2) zu zirkulieren.
 9. Das Funkkommunikationsgerät nach Anspruch 1, **dadurch gekennzeichnet, dass** das erste Übertragungssignal eine erste Frequenz aufweist, das zweite Übertragungssignal eine erste Phase und eine zweite Frequenz aufweist, und dass das Funkkommunikationsgerät ferner umfasst: einen Filterschaltkreis, dazu ausgebildet, das erste und zweite Übertragungssignal jeweils an die Antenne (101) und das Antennen(101)-Reflexionssignal an den Phasendetektionsschaltkreis (104) zu übertragen und zu verhindern, dass das Antennen(101)-Reflexionssignal

xionssignal an den ersten Übertragungsschaltkreis (105) überführt wird.

10. Ein Verfahren zum Einstellen einer variablen Impedanz in einem mit einer Antenne (101) verbundenen Impedanzanpassungsschaltkreis (102), **dadurch gekennzeichnet, dass** es folgende Schritte umfasst:

Zuführen einer elektrischen Leistung zu einem ersten Übertragungsschaltkreis (105), um ein erstes Übertragungssignal zu erzeugen, und Zuführen des ersten Übertragungssignals an die Antenne (101), durch den Impedanzanpassungsschaltkreis (102) und Kommunizieren mit dem anderen Kommunikationsgerät; Detektieren der an den ersten Übertragungsschaltkreis (105) zugeführten, elektrischen Leistung und Erzeugen eines Leistungsdetektionssignals; Detektieren eines Antennenreflexionssignals, das eine Phase aufweist und das von der Antenne (101) zurückgegeben wird; und Einstellen der variablen Impedanz eines Impedanzanpassungsschaltkreises (102) in Abhängigkeit von dem Leistungsdetektionssignal, um die Antenne (101) an den ersten Übertragungsschaltkreis (105) anzupassen:

dadurch gekennzeichnet, dass das Einstellen der variablen Impedanz umfasst:

Erzeugen eines zweiten Übertragungssignals mit einer ersten Phase mittels eines zweiten Übertragungsschaltkreises (104-1) und Zuführen des zweiten Übertragungssignals an die Antenne (101), die ein Antennen(101)-Reflexionssignal mit einer von dem zweiten Übertragungssignal abhängenden, zweiten Phase erzeugt; Empfangen des zweiten Übertragungssignals und des Antennenreflexionssignals; Detektieren einer Phasendifferenz zwischen der ersten und zweiten Phase, um ein Phasendetektionssignal zu erzeugen, und Steuern der variablen Impedanz in Abhängigkeit von dem Phasendetektionssignal zusätzlich zu dem Leistungsdetektionssignal.

Revendications

1. Equipement de communication radio comprenant :

une alimentation (107) configurée pour appliquer une puissance électrique ;
un premier circuit d'émission (105) configuré pour générer un premier signal d'émission pour communiquer avec un autre équipement de

communication, lequel est alimenté par l'alimentation (107) ;

un circuit de détection de puissance (106) configuré pour détecter la puissance électrique appliquée sur le premier circuit d'émission (105) et pour générer un signal de détection de puissance ;

une antenne (101) présentant une impédance d'antenne sur laquelle le premier signal d'émission est appliqué et qui génère un signal de réflexion d'antenne présentant une certaine phase qui dépend du premier signal d'émission ;

un circuit d'adaptation d'impédance (102) qui présente une impédance variable, configuré pour régler l'impédance variable de manière à adapter l'antenne (101) vis-à-vis du premier circuit d'émission (105) ; et

un circuit de commande (108) configuré pour commander le circuit d'adaptation d'impédance (102) pour établir l'impédance variable en fonction du signal de détection de puissance,

caractérisé en ce que l'équipement de communication radio comprend en outre :

un circuit de détection de phase (104) configuré pour générer un signal de détection de phase, le circuit de détection de phase (104) incluant :

un second circuit d'émission (104-1) configuré pour générer un second signal d'émission présentant une première phase et pour appliquer le second signal d'émission sur l'antenne (101), l'antenne (101) générant un signal de réflexion d'antenne présentant une seconde phase en fonction du second signal d'émission ; et

un circuit de réception (104-2) configuré pour recevoir le second signal d'émission en provenance du second circuit d'émission (104-1) et le signal de réflexion d'antenne en provenance de l'antenne (101) et pour détecter une différence de phase entre les première et seconde phases afin de générer le signal de détection de phase ; et le circuit de commande (108) est configuré pour commander le circuit d'adaptation d'impédance (102) afin d'établir l'impédance variable en fonction du signal de détection de phase en plus du signal de détection de puissance.

2. Equipement de communication radio selon la revendication 1, **caractérisé en ce que** l'équipement de communication radio comprend en outre un circuit de sélection (103) configuré pour sélectionner soit le circuit de détection de phase (104), soit le premier circuit d'émission (105) et pour connecter le circuit

- sélectionné pris parmi le circuit de détection de phase (104) et le premier circuit d'émission (105) à l'antenne (101), et le circuit de commande (108) est configuré pour commander le circuit de sélection (103) pour recevoir le signal de détection de phase et le signal de détection de puissance.
3. Equipement de communication radio selon la revendication 2, **caractérisé en ce que** le circuit de commande (108) est configuré pour générer les premier et second signaux de sélection et pour appliquer les premier et second signaux de sélection sur le circuit de sélection (103), le circuit de sélection (103) étant configuré pour connecter l'antenne (101) au circuit de détection de phase (104) en réponse au premier signal de sélection et pour connecter l'antenne (101) au circuit d'émission (105, 104-1) en réponse au second signal.
 4. Equipement de communication radio selon la revendication 1, **caractérisé en ce que** le circuit de commande (108) est configuré pour stocker un signal de phase de référence et un signal de puissance de référence et pour régler l'impédance du circuit d'adaptation d'impédance (102) conformément à la comparaison entre le signal de détection de phase et le signal de phase de référence ainsi qu'entre le signal de détection de puissance et le signal de puissance de référence.
 5. Equipement de communication radio selon la revendication 3, **caractérisé en ce que** le circuit de commande (108) est configuré pour déterminer un procédé de réglage du circuit d'adaptation d'impédance (102) en fonction de la comparaison entre le signal de détection de phase et le signal de phase de référence et pour comparer le signal de détection de puissance avec le signal de puissance de référence afin d'établir l'impédance variable dans le circuit d'adaptation d'impédance (102).
 6. Equipement de communication radio selon la revendication 5, **caractérisé en ce que** le procédé de réglage correspond à soit une augmentation, soit une diminution de l'impédance variable.
 7. Equipement de communication radio selon la revendication 1, **caractérisé en ce qu'il** comprend en outre une seconde antenne (101-2) connectée à l'antenne (101), les première et seconde antennes (101, 101-2) étant couplées électromagnétiquement l'une à l'autre.
 8. Equipement de communication radio selon la revendication 1, **caractérisé en ce que** le circuit de détection de phase (104) inclut en outre une ligne de retard (104-4) qui est configurée pour retarder le second signal d'émission depuis le second circuit
- d'émission (104-1) jusqu'à l'antenne (101) et pour retarder le signal de réflexion d'antenne (101) depuis l'antenne (101) jusqu'au circuit de réception (104-2) ; et
- un circulateur (104-3) configuré pour faire circuler le signal de réflexion d'antenne (101) retardé jusqu'au circuit de réception (104-2) et pour faire circuler le second signal d'émission depuis le second circuit d'émission (104-1) jusqu'à la ligne de retard (104-4) et jusqu'au circuit de réception (104-2).
9. Equipement de communication radio selon la revendication 1, **caractérisé en ce que** le premier signal d'émission présente une première fréquence, le second signal d'émission présente une première phase et une seconde fréquence et l'équipement de communication radio comprend en outre un circuit de filtre configuré pour faire passer les premier et second signaux d'émission à l'antenne (101) et le signal de réflexion d'antenne (101) au circuit de détection de phase (104), de façon respective, et pour empêcher que le signal de réflexion d'antenne (101) ne soit transféré sur le premier circuit d'émission (105).
 10. Procédé de réglage d'une impédance variable dans un circuit d'adaptation d'impédance (102) connecté à une antenne (101), **caractérisé en ce qu'il** comprend :

l'application d'une puissance électrique sur un premier circuit d'émission (105) pour générer un premier signal d'émission et - l'application du premier signal d'émission sur l'antenne (101) par l'intermédiaire du circuit d'adaptation d'impédance (102) et la communication avec un autre équipement de communication ;

la détection de la puissance électrique appliquée sur le premier circuit d'émission (105) et la génération d'un signal de détection de puissance ;

la détection d'un signal de réflexion d'antenne présentant une phase, lequel signal est retourné depuis l'antenne (101) ; et

le réglage de l'impédance variable d'un circuit d'adaptation d'impédance (102) en fonction du signal de détection de puissance afin d'adapter l'antenne (101) vis-à-vis du premier circuit d'émission (105),

caractérisé en ce que :

le réglage de l'impédance variable inclut :

la génération d'un second signal d'émission présentant une première phase au moyen d'un second circuit d'émission (104-1) et l'application du second signal d'émission

sur l'antenne (101) qui génère un signal de réflexion d'antenne (101) présentant une seconde phase en fonction du second signal d'émission ;
la réception du second signal d'émission et du signal de réflexion d'antenne ;
la détection d'une différence de phase entre les première et seconde phases afin de générer un signal de détection de phase ; et
la commande de l'impédance variable en fonction du signal de détection de phase en plus du signal de détection de puissance.

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FIG. 1

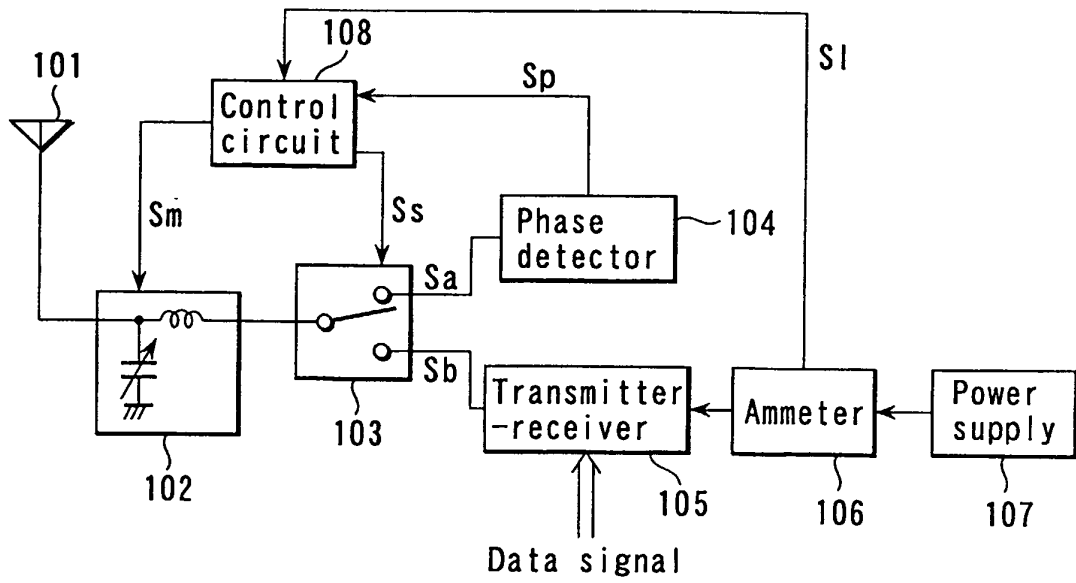
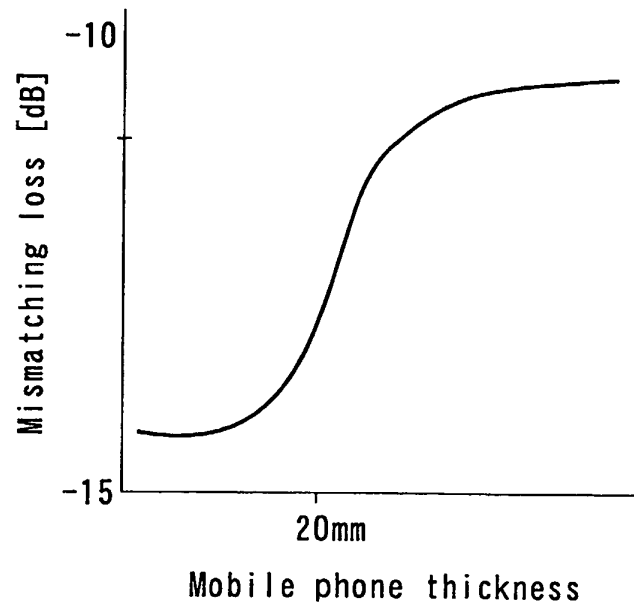


FIG. 2

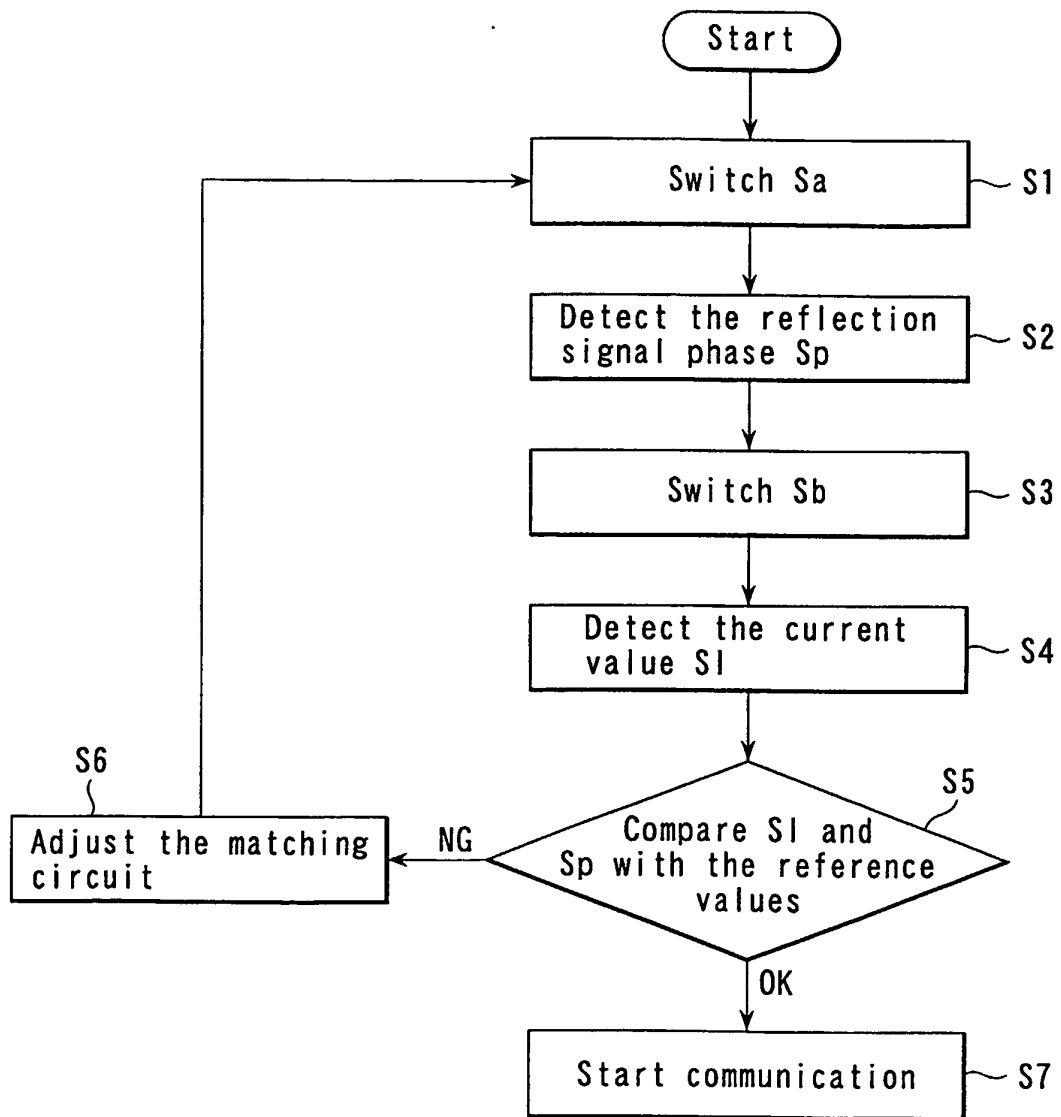
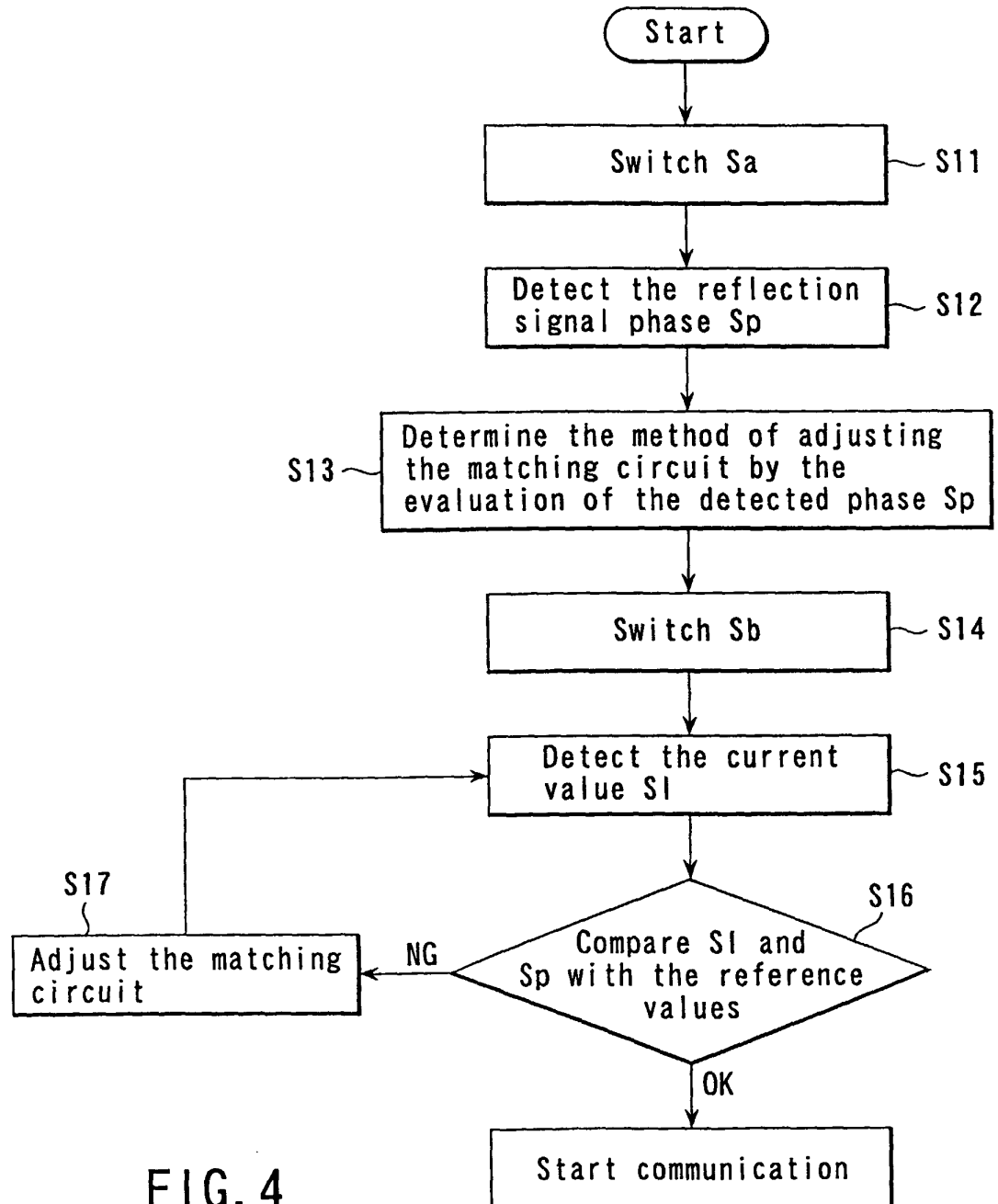


FIG. 3



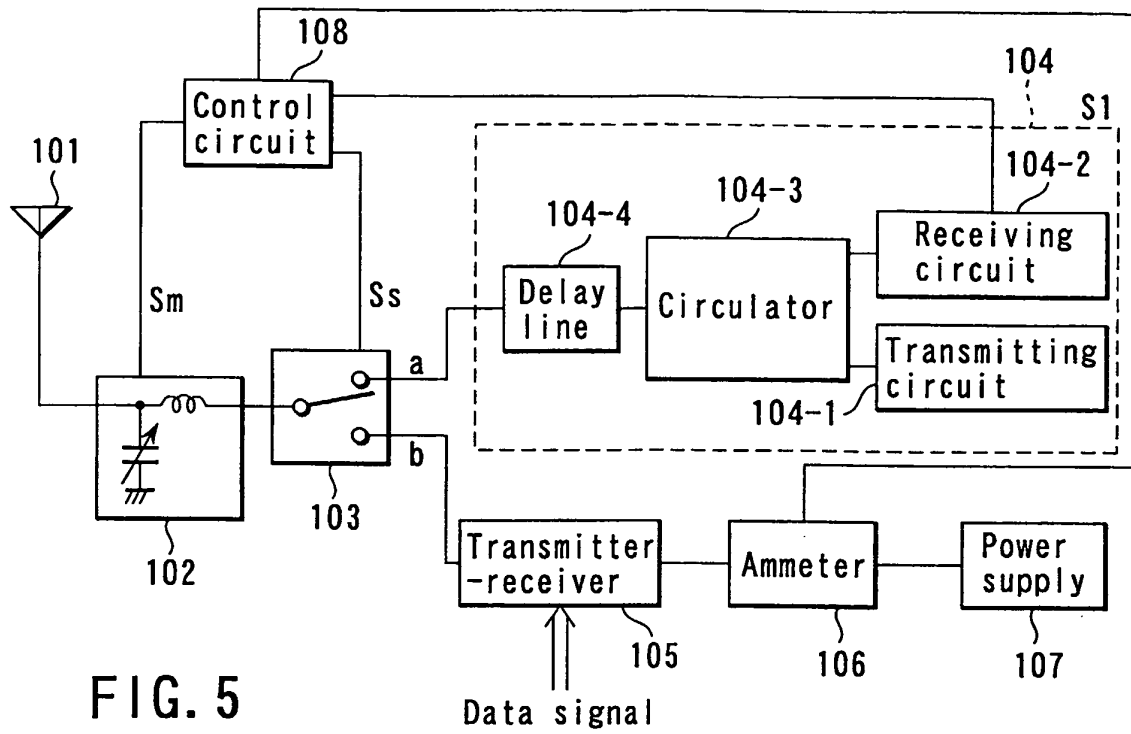


FIG. 5

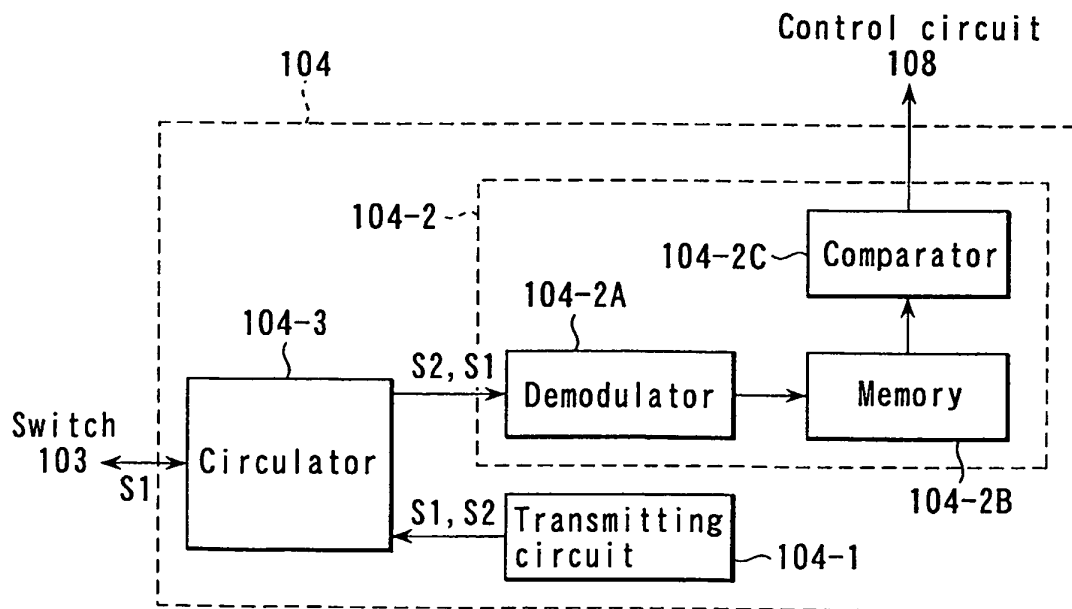
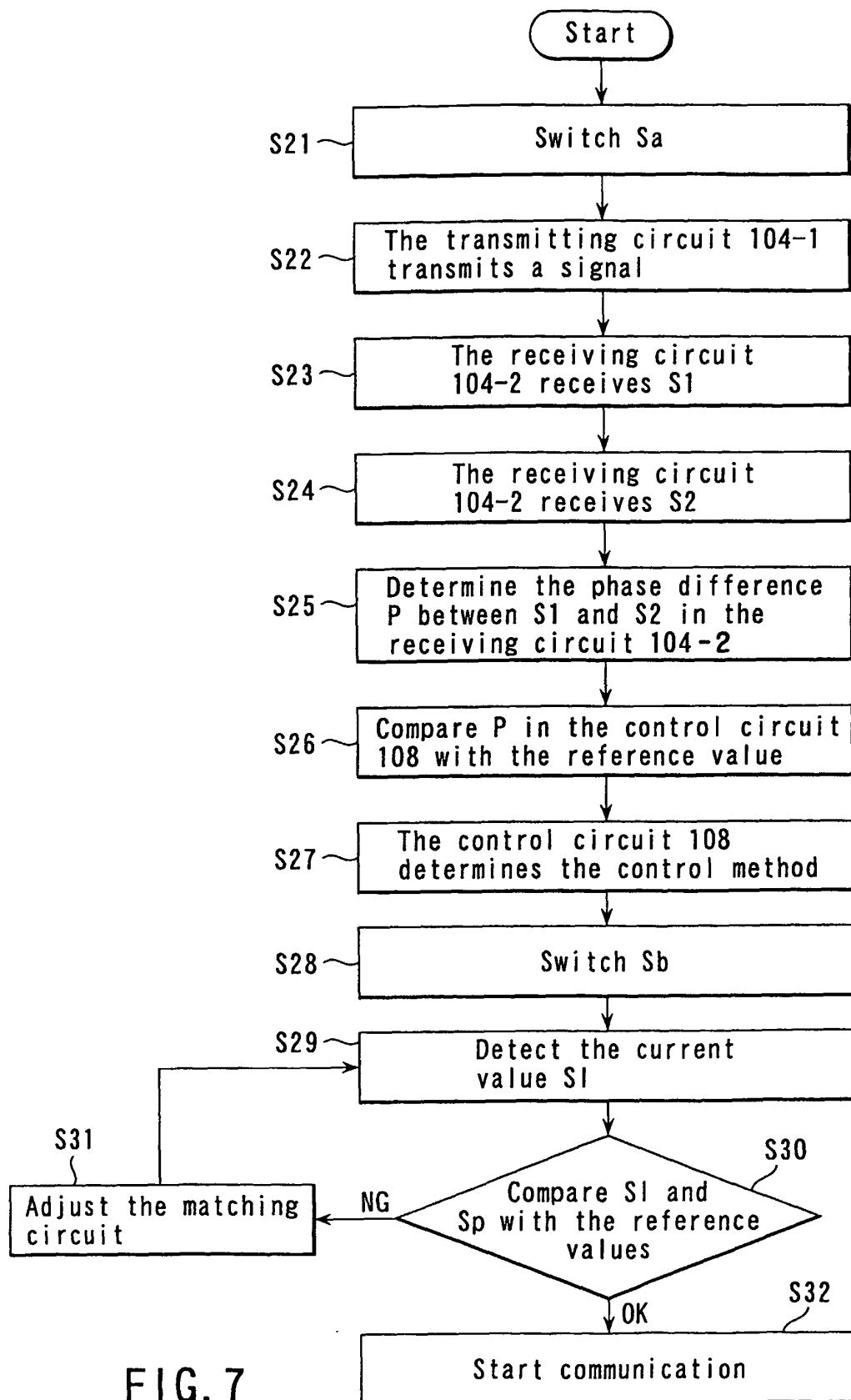


FIG. 6



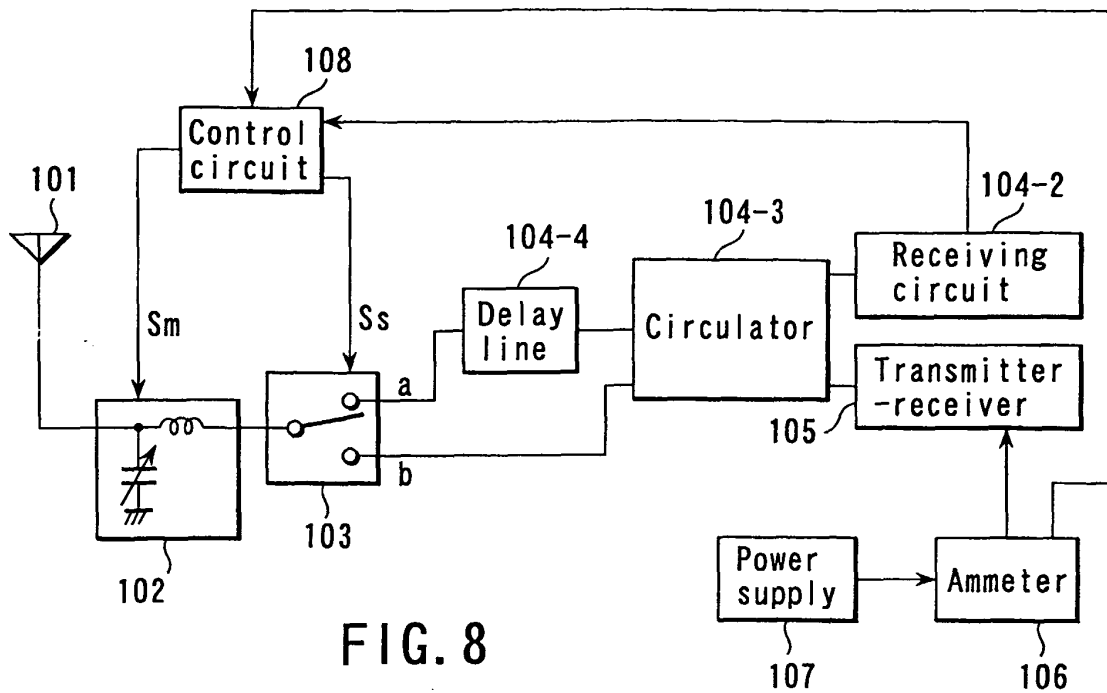


FIG. 8

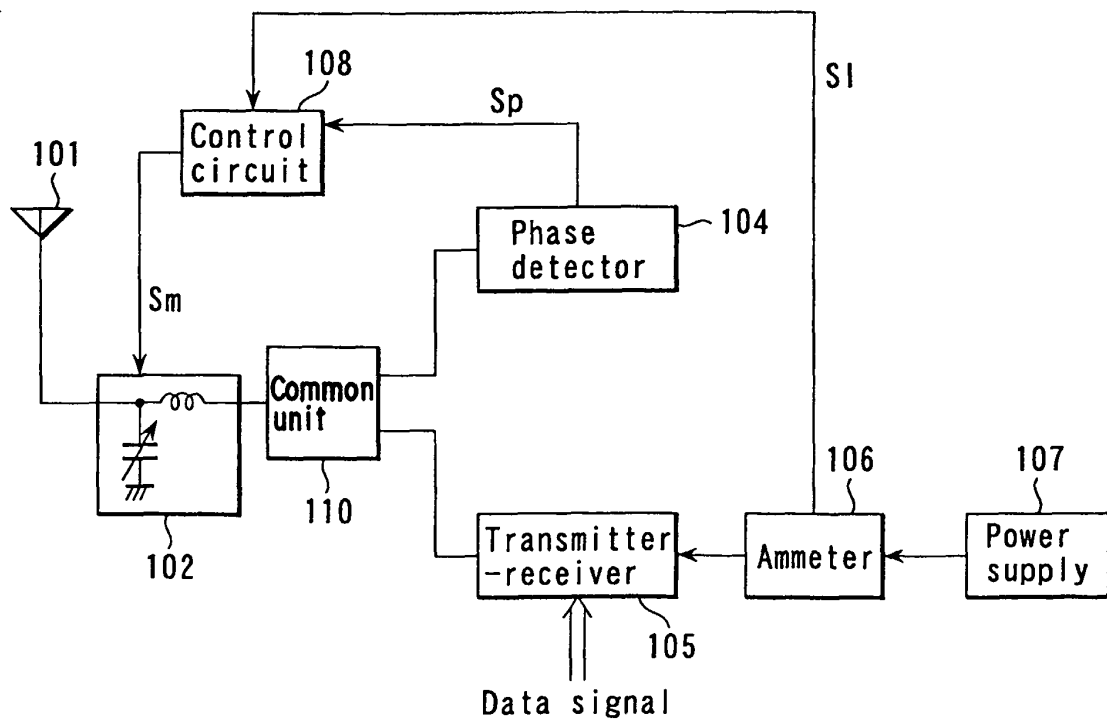


FIG. 9

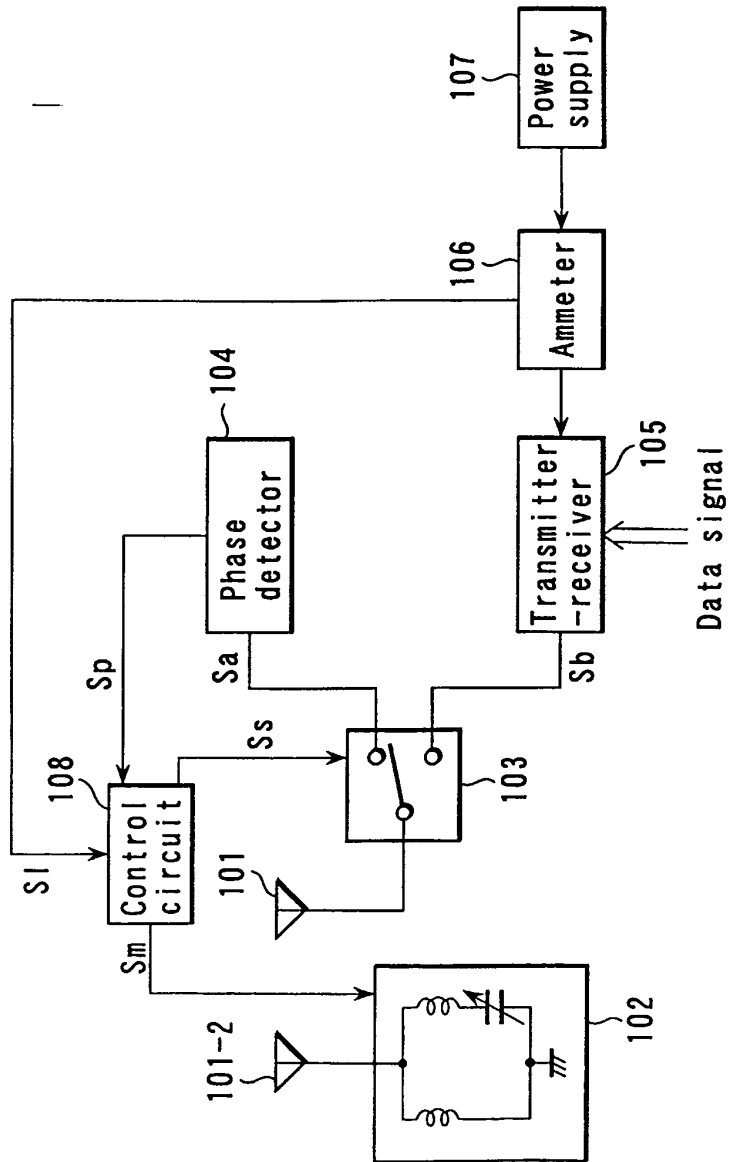


FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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